HABITAT SUITABILITY CRITERIA FOR ASSESSMENT OF INSTREAM FLOW NEEDS OF FISH

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REFERENCE: *Proceedings of the 1989 Georgia Water Resources Conference,* held May 16 and 17, 1989, at The University of Georgia. Kathryn J. Hatcher, Editor, Institute of Natural Resources, The University of Georgia, Athens, Georgia, 1989.

INTRODUCTION

In the western portion of the United States, competition for stream water has often been fierce. Water resource management agencies in the southeastern United States, where water has been relatively abundant, are now being faced with similar competing demands for water, and with increasing pressures to develop and defend recommendations for protecting fish and invertebrates in streams. Streamflow depletion at any time can result in severe long-term effects on fish populations (Peters, 1982).

The allocation of stream water to any of numerous instream or offstream uses is tied to the issues of water quantity, quality, and timing, which center on two critical questions: (1) when and how much water of an acceptable quality should be left in a stream, and (2) what happens if flow regimes are changed? Answers to these questions will probably be complex, but reliable answers are needed to protect instream and offstream values. If instream flow interests expect to compete with offstream uses for limited water supplies, they must be able to establish reliable and defensible methods for determining instream flow needs and demonstrate the environmental consequences of altered flow regimes.

My objectives in this paper are: (a) to present an overview of the need, development, and use of stream habitat suitability criteria, and the use of these criteria for the assessment of instream flow needs; (b) to give a status report on the plan of the National Ecology Research Center (NERC) for expansion of instream flow research in the Southeast; and (c) to discuss the relevancy of the research to river corridor management.

STREAM HABITAT SUITABILITY CRITERIA AND EVALUATION METHODS

Fishing, boating, wading, and swimming are some uses of water flowing in a stream (i.e., instream flow). The need for stream habitat criteria (Bovee, 1986) and methods useful for evaluating instream flow values for fishery resources was first recognized in the western United States during the 1950's and 1960's (Trihey and Stalnaker, 1985). As instream uses and values became more widely recognized and competition for water grew, many useful methods evolved for identifying, evaluating, recommending, and managing instream flows (e.g., Tennant, 1976; Stalnaker, 1979; Loar and Sale, 1981; Newcombe, 1981; Trihey and Stalnaker, 1985; Filipek et al., 1987; Jacobs et al., 1987).

Methods for evaluating instream flow needs are in two general categories: (1) "standard-setting" or threshold, and (2) "incremental" (Trihey and Stalnaker, 1985). Standard setting refers to the measurements and interpretive techniques designed to generate a flow recommendation that is intended to maintain the fishery at some acceptable level. Most of the instream flow evaluation methods developed to date are standard-setting. However, standard-setting methods (e.g., the 7-day Q10 standard) yield threshold or single-flow recommendations, and have only limited ability to incorporate biological or hydrological information. The methods may be useful for setting flow standards in many situations but are not designed to answer an important question: What happens to the fishery habitat if the streamflow (standard) identified for maintaining the fishery habitat is not delivered? This question can usually be answered best by the incremental approach.

The incremental approach for evaluating instream flow needs of fish evolved in the western United States for coldwater species (Collins et al., 1972; Dooley, 1976; Waters, 1976). The synthesis and refinement of these and other concepts led to the development of the Instream Flow Incremental Methodology or IFIM (Stalnaker, 1979; Orth and Maughan, 1982). This habitat-based, state-of-the-art methodology has been widely applied for evaluating instream flow needs for coldwater fishes.

Prerequisite and probably the single greatest constraint to applying the IFIM is knowledge of the microhabitat preferences or suitability of the species targeted for evaluation. This information is usually presented in the form of habitat suitability criteria or Suitability Index (SI) curves (Bovee, 1986). The SI curves are used with the Physical Habitat Simulation System or PHABSIM (Milhous et al., 1984) to compute habitat availability under various simulated flow regimes. The physical models within PHABSIM describe how the environment changes with respect to streamflow and translates streamflow to weighted usable area of habitat. This translation enables quantification of the amount of potential habitat available for a species and life history phase in a given reach of stream under various flow regimes, and enables the development of habitat time series. One underlying assumption of the IFIM is that there is a positive relation between the weighted usable area of habitat for the controlling life stage and the standing stock of the fish species being evaluated. This underlying assumption of IFIM (and some others) has not been validated to the satisfaction of some critics (Mathur et al., 1985; Shirvell, 1986). Nevertheless, IFIM has been shown to be a defensible technique for adjudicating flow regimes needed to support fish populations and to maintain other identified instream values at desired levels--particularly for western United States streams dominated by snowmelt hydrology and salmonid fishes (Cavendish and Duncan, 1986; Garn, 1986; Gore and Nestler, 1988).

STREAM IMPACT ASSESSMENT IN THE SOUTHEAST

The strength of IFIM lies in its ability to estimate the effects of various flow regimes on fish habitat when quantitative information on microhabitat preferences (i.e., habitat suitability) for the species of concern is known (Orth and Maughan, 1982). In spite of this strength and its wide application in coldwater streams, IFIM has not received high acceptance for use in warmwater streams; the reasons probably include the high species diversity and lack of SI curves for many of the species, and fundamental differences in warmwater and coldwater fish communities (Bain, 1988).

As judged from surveys conducted by the Aquatic Systems Branch of NERC, the most important issues related to the effects of instream flow expected in the Southeast over the next decade are rapid fluctuation of flows, periodic dewatering, major reductions in streamflow, and reduced habitat quality and quantity for riverine species. Three critical questions related to these anticipated impacts need answers for use in instream flow impact assessment: (1) Do warmwater species and assemblages have measurable microhabitat preferences?; (2) What are the most important physical variables that determine microhabitat suitability?; and (3) If physical variables control microhabitat suitability, can they be quantified for practical application in instream flow management for warmwater streams?

In general, the Southeast lacks a regionally accepted approach to stream habitat assessment, and little work is under way to develop one (Bain, 1988). The primary objective of the project begun by NERC in the Southeast is to mount a sustained research effort directed toward developing a new or modified stream impact assessment approach acceptable for use in warmwater streams of the area. To implement this mission, NERC will use research work orders with Cooperative Fish and Wildlife Research Units, and research by a stream ecologist and a fishery biologist stationed at a NERC instream flow research field station being established at Auburn University, Alabama. The Fort Collins, Colorado, staff of NERC will provide the field station with expertise in fields such as hydrology, engineering, economics, modeling, and training.

Two instream flow studies supported by NERC are underway in the Southeast. One study focuses on the development of habitat suitability criteria for species of common and endangered freshwater mussels and species of fish that are host to mussel larvae. Streams in the Southeast contain the most diverse assemblage of freshwater mussels in the world. Without a detailed knowledge of flow-dependent habitat requirements for mussels and their host fish species, resource agencies are hampered in providing defensible instream flow recommendations for the protection and enhancement of mussel populations. This mussel study was started in mid-1988 and is to end in 1991.

The second instream flow study currently being supported by NERC in the Southeast focuses on the determination of relations between warmwater stream habitats, flow regimes, and fish communities, and on the development of new or modified stream impact assessment approaches for warmwater streams. The study involved two initial tasks: (1) conducting a literature review on regulated streamflow and warmwater stream fish communities, and (2) developing a general hypothesis of the effects of regulated flow on fishes and invertebrates. This hypothesis will be a framework for designing and conducting a sequence of tests directed toward developing a documented and generalized model of the effects of flow regulation on warmwater stream fishes and aquatic invertebrates. Detailed results of these two completed tasks are available (Bain, 1988). Sampling sites for this study are to be in the Alabama River basin. Field work was started in 1988 and the study is to end in 1993.

STREAM FISHERIES AND CONCOMITANT WETLANDS

A secondary objective of the NERC field station established at Auburn will be to identify and quantify functional relations between stream corridor fisheries and concomitant forested palustrine wetlands. Riparian wetlands that flank many of the major streams in the Southeast are coupled to river corridors by way of a "water bridge," at least during flooding. It is generally known, but not sufficiently quantified or substantiated, that such wetlands provide spawning, feeding, and cover habitat for many fish species (Crance, 1988). They also import, store, produce, and recycle materials used in food chains *in situ* by numerous organisms, including fish. Furthermore, some residual materials are exported from the wetlands to downstream aquatic systems where the materials are available for use in food chains. These riparian wetlands exist as a result of hydrologic regimes. The timing, magnitude, and duration of flooding are primary determinants of the wetland's structure and function, but these variables have not been sufficiently quantified relative to fish habitat suitability. A better understanding of the relations between streamflows and hydrologic regimes required for the well-being of palustrine-related fisheries will provide information useful for the management of river corridor resources.

CONCLUSION

Significant advances in instream flow assessment have been made over the past several decades, but much more research is needed to advance the state of the art, especially for warmwater streams. It is hoped that research begun by NERC in the Southeast will provide some of the criteria needed for the evaluation and protection of instream flows and will serve as a stimulus for more comprehensive and cooperative research in warmwater stream ecology in this region.

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